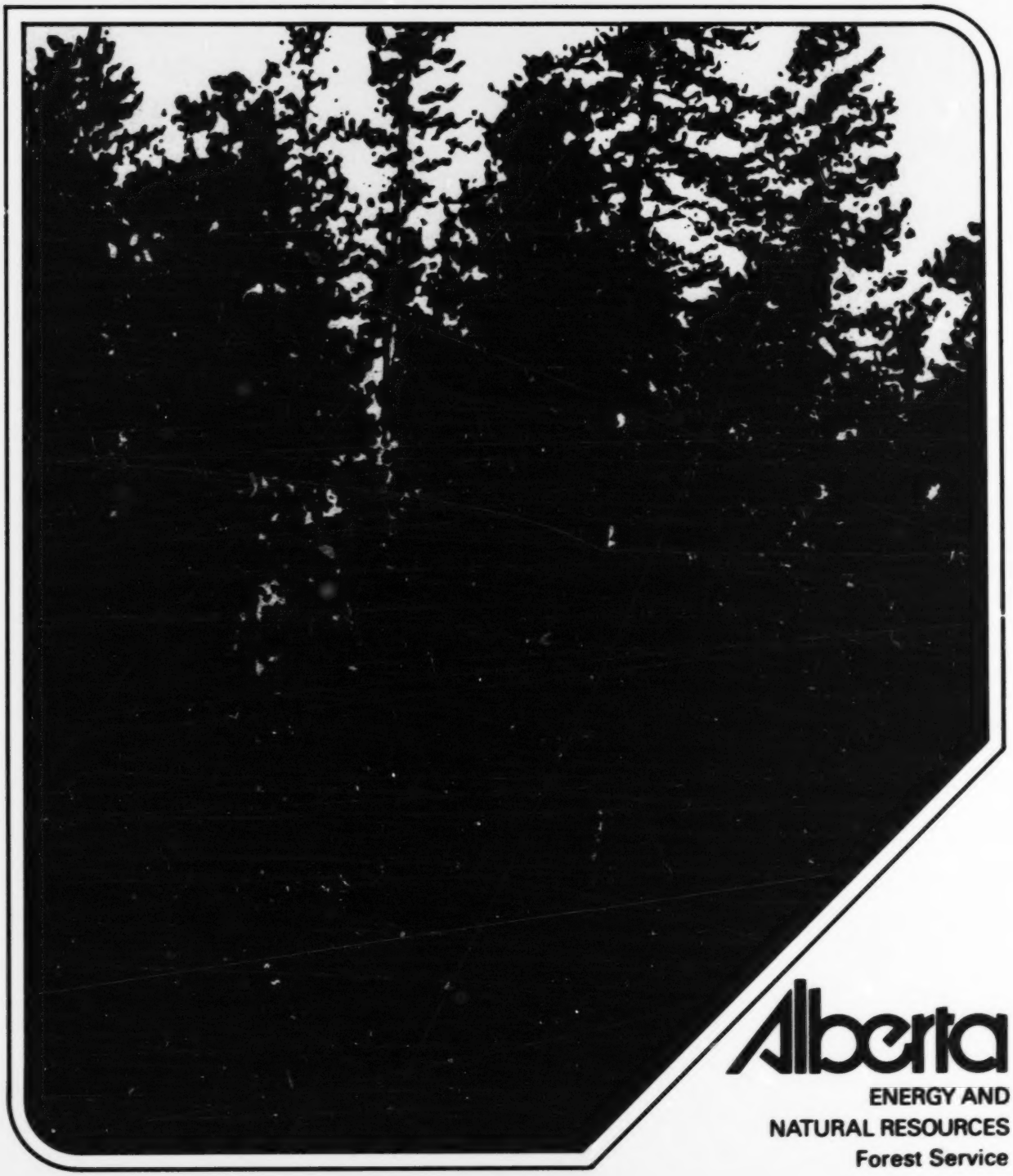
WILDFIRE BEHAVIOR ASSOCIATED WITH UPPER RIDGE BREAKDOWN



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Wildfire Behavior Associated with Upper Ridge Breakdown
(1983) by Nicholas Nimchuk.

- Title Page -- Include the following acknowledgement below author's name:

  "Meteorologist, Forest Protection Branch
  Alberta Forest Service".

- Page vii -- In Table of Contents change page number for sub-sections 2.2, 2.3 and 2.4 from "5" to "4a".

- Page 4 -- Insert Page 4a.

- Page 5 -- In the first line of the page, "Weather conditions..." should read "weather conditions...".

- Page 44 -- Under Stage 2, in the first line "short wave trough" should read "short wave troughs".

2.2 Fire Weather Data

The fire-weather observations [3] used in this report were taken by Alberta Forest Service fire lookouts and ranger stations in the Footner Lake and Athabasca forests (Fig. 2) in proximity to the major problem fires. Surface weather and upper air charts were prepared from data collected at AES or Transport Canada observation stations located at major airports and AES upper air sounding facilities. Data from American stations used in the report were complied from the AES teletype network. The AFS Weather Section is able to access the network through a dedicated teletype circuit.

2.3 Wildfire Statistics

The daily number of hectares burned and lightning fire starts on a provincial basis were extracted from the 1981 AFS Fire Situation Reports (SITREPS). Daily area burned was calculated by taking the difference between the total area burned to daie of consecutive days during the study period. The daily number of lightning fire starts occurring on a given day was taken to be the number of lightning starts reported on the SITREPS of the following day.

2.4 Synoptic Anomalies and Related Fire-Weather Conditions

A positive anomaly of the 500 MB height usually indicates an upper level ridge of high pressure is near or over the station while a negative anomaly indicates the presence of an upper trough or low. The fire

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[3]Fire weather observations are taken at local noon standard time or 1300 local daylight saving time. In this report all fire weather observations were taken at 1300 Mountain Daylight Time and previous 24-hour total of water equivalent precipitation are used to calculate the fuel moisture codes and fire behavior indices of the Canadian Forest Fire Danger Rating System (CFFDRS).

WILDFIRE BEHAVIOR ASSOCIATED WITH UPPER RIDGE BREAKDOWN

by
Nicholas Nimchuk

1983
Edmonton

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Natural Resources
Forest Service

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ABSTRACT

The 1981 Alberta fire season witnessed a record 1 486 fires burn 1.26 million hectares (ha) of forest land. The fire statistics point toward two short but catastrophic burning periods:

1. August 25 to 27 (0.509 million ha)
2. September 15 to 19 (0.464 million ha).

The area consumed during these eight days accounted for 77% of the total fire losses in 1981. On August 27 alone 376 000 ha were burned in slightly less than seven hours. The Footner Lake and Athabasca forests suffered the majority (92%) of the total provincial losses during the 1981 season.

As in other active fire seasons of the past, the weather played a significant role during the particularly severe 1981 season. More specifically, breakdowns of established upper level ridge circulation patterns were associated with explosive runs taken by on-going fires. The literature contains only a few studies relating fire behavior to the upper level ridge pattern. These studies emphasize the presence of the ridge as the primary agent responsible for extreme fire behavior incidents. This study shows that although the forest fuels are brought to a critically dry state by a stationary ridge, extreme fire behavior is seldom observed in areas dominated by a ridge pattern.

This study examines the fire-weather conditions associated with the critical burning periods of 1981 and clearly identifies the breakdown, rather than the presence, of a persistent upper ridge as the trigger for extreme fire behavior.

ACKNOWLEDGMENTS

The author wishes to extend his appreciation to a number of individuals whose contributions to the preparation in this report were most helpful.

Ben Janz, Fire Weather Officer, Alberta Forest Service, provided the necessary time and offered valuable guidance throughout. M.E. Alexander, Fire Research Officer, Canadian Forestry Service, gave significant aid through a critical review of the draft and data collection. Roger Street, Atmospheric Environment Service, Environment Canada, retrieved important upper air data after all conventional channels had been exhausted. Ray Schmidt, Federal Department of Indian Affairs and Northern Development, also reviewed the draft and gave enthusiastic support for its completion.

Ms. Myrna Delaney and Ms. Darlene Tymchuk patiently typed the early drafts.

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1. INTRODUCTION

The wildfire environment is shaped by the elements of fuels, topography and weather. By its very nature the weather is the most variable of these elements and is the key factor in determining fire danger and behavior. Whether a fire remains manageable or becomes an explosive, uncontrollable conflagration is highly dependent on the weather.

The weather at the surface of the earth is directly influenced by the flow or circulation of the upper atmosphere. The pattern of this upper level circulation is generally described in terms of ridges and troughs. Surface weather conditions associated with these two patterns are well known. During the fire season in Alberta, an upper level ridge results in the building of a surface high pressure area, very warm or hot temperatures, low relative humidities, light winds and little precipitation. Consequently an upper ridge may produce rapid fuel build-up and more active behavior of existing fires. The upper level trough on the other hand is normally accompanied by a low pressure system at the surface and typically produces cool, humid weather and stronger winds and may bring significant amounts of precipitation. Fire danger is generally low under an established upper trough.

Although the upper level flow pattern is dynamic and undergoes continuous change, certain patterns will often exhibit a high degree of persistence. An upper ridge or trough can remain essentially stationary over an area, giving a prolonged period of warm and dry or cool and damp weather, respectively. An upper ridge that displays little movement over several days is frequently referred to as a 'blocking ridge'. Extreme fuel build-up arising from a blocking ridge, aggravated by below-normal seasonal precipitation, established the environment which led to record-breaking fire losses in Alberta during 1981. Past fire-weather studies have tended to imply that extreme fire behavior incidents are largely

attributable to the presence of a blocking ridge. Although the fuels are usually brought to a critical state by a blocking ridge, the study presented here shows that blow-up[1] fires in 1981 occurred during the relatively brief period of collapse of the upper ridge. The transition from the upper ridge to the upper trough pattern is frequently accompanied by a surface low pressure system which produces stronger winds, eventual cooling and higher relative humidities. Before the cooler air and moisture advection occur, however, a period of several hours during which the surface winds become significantly stronger may develop. It is within this period of strong winds, high temperature, low relative humidity and critically dry fuel conditions that blow-up fire potential reaches a maximum.

When examined from a fire environment perspective, the life time of an upper ridge apparently consists of three stages:

1. An establishment period producing rapidly increasing temperatures, light winds, low humidities, reduction in fuel moisture and stable atmospheric conditions that inhibit lightning ignition;
2. A mid-life stage characterized by high to extreme fire-weather conditions. Slight weakening, leading to greater lightning ignition potential, followed by subsequent recovery of the ridge pattern is often observed;
3. The final breakdown of the ridge by an upper low pressure system or trough accompanied by strong winds, high thunderstorm risk, eventual cooling and increasing relative humidity. A heightened chance of precipitation is also present in this final stage.

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[1]A blow-up fire is defined as a fire which suddenly increases its rate of spread, intensity and rate of energy output by several times (Byram 1954).

The risk of extreme fire behavior appears greatest during the breakdown period.

In the past, fire control personnel seem to have overlooked the transitional period from the ridge to trough pattern in anticipation of the precipitation relief that may accompany an upper trough. Unfortunately, as past studies[2] and this study of 1981 in particular have shown, the ridge breakdown may produce very little effective precipitation and serve only to create a brief but exceedingly volatile burning period over a wide geographical area.

The establishment of an upper ridge raises several implications in all aspects of fire suppression and management activities. Considerations range from the increase in man-caused ignition risk during the early stage of ridge development to resource deployment and fire-line safety at the breakdown. Particularly severe problems are highly probable if a high fire load exists immediately prior to the ridge collapse. Fire managers and fire-weather meteorologists alike must be acutely aware of the potential impact of an upper ridge collapse on wildfire behavior.

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[2] Alexander, Janz, and Quintilio. Analysis of Extreme Wildfire Behavior in East-Central Alberta: A Case Study. This paper presented at the Seventh Conference on Fire and Forest Meteorology in April, 1983, documents the fire-weather conditions that produced a blow-up fire (DND-4-80) in the Lac La Biche forest on May 2, 1980. The breakdown of a blocking ridge that had dominated the weather over Alberta for most of April, 1980, established a blow-up environment and resulted in an extreme fire behavior incident on DND-4-80.

2. WEATHER DATA AND FIRE STATISTICS

2.1 Anomaly Charts

The Weather Section of the Alberta Forest Service (AFS) maintains a daily record of the deviations from or anomalies of long-term normal values of the height of the 500 millibar (MB) pressure level and the maximum surface temperature (°C) at Edmonton, Alberta (Canadian Normals: Temperature and Precipitation: 1941-1970). The 500 MB data were obtained from the Atmospheric Environment Service (AES) upper air sounding station at Stony Plain, Alberta, located 45 km west of Edmonton. The maximum surface temperature data were obtained at the Edmonton Municipal (formerly the Industrial) airport.

The anomalies are recorded graphically using a single monthly chart for both sets of data. Pressure level heights are normally expressed in geopotential metres above sea level (ASL). The 500 MB height usually ranges from 5 300 to 5 900 metres ASL over Alberta during late spring and summer. For map and chart plotting purposes, the first and last digits of the height value are deleted (e.g., a height of 5 720 metres is plotted as 72). This coding allows display of both sets of data along a common vertical axis. An anomaly chart (Fig. 1) is initially prepared by drawing curves of the long-term normal values of 500 MB height and maximum surface temperature. The actual daily values are then plotted chronologically and connected by straight lines. Values above the mean curves indicate a positive anomaly and those below a negative anomaly.

Weather conditions associated with an established upper ridge during fire season in Alberta are well known:

1. A surface high pressure builds beneath the ridge;
2. Warm or occasionally very high temperatures;
3. Low relative humidities;
4. Little or no precipitation;
5. Generally light winds;
6. A low risk of lightning ignition.

Unstable conditions are often observed in the atmospheric layer near the ground during periods of very high temperature. However, the overall dryness and tendency toward stabililty throughout the entire depth of the atmosphere under a strong ridge suppresses thunderstorm development.

An upper ridge that remains essentially stationary over a given area is clearly conducive to drying of the forest fuels and increasing fire danger. Conversely, the upper low or trough typically brings fire-weather conditions which tend to reduce fire danger:

1. A surface low pressure system, trough or frontal wave, usually preceding the upper system;
2. Below-normal temperatures;
3. High relative humidities;
4. A definite risk of precipitation. Heavy precipitation events in Alberta are usually the result of an upper low;
5. A period of higher lightning risk. The ignition potential of the lightning tends to be reduced by the effects of factors two to four above on fuel moisture.

The wave like pattern of ridges and troughs in the upper level flow largely determines the weather at the surface. Upper ridges and troughs are seldom static; however, certain upper flow patterns may exhibit a high degree of persistence. Well developed upper ridges and troughs have been

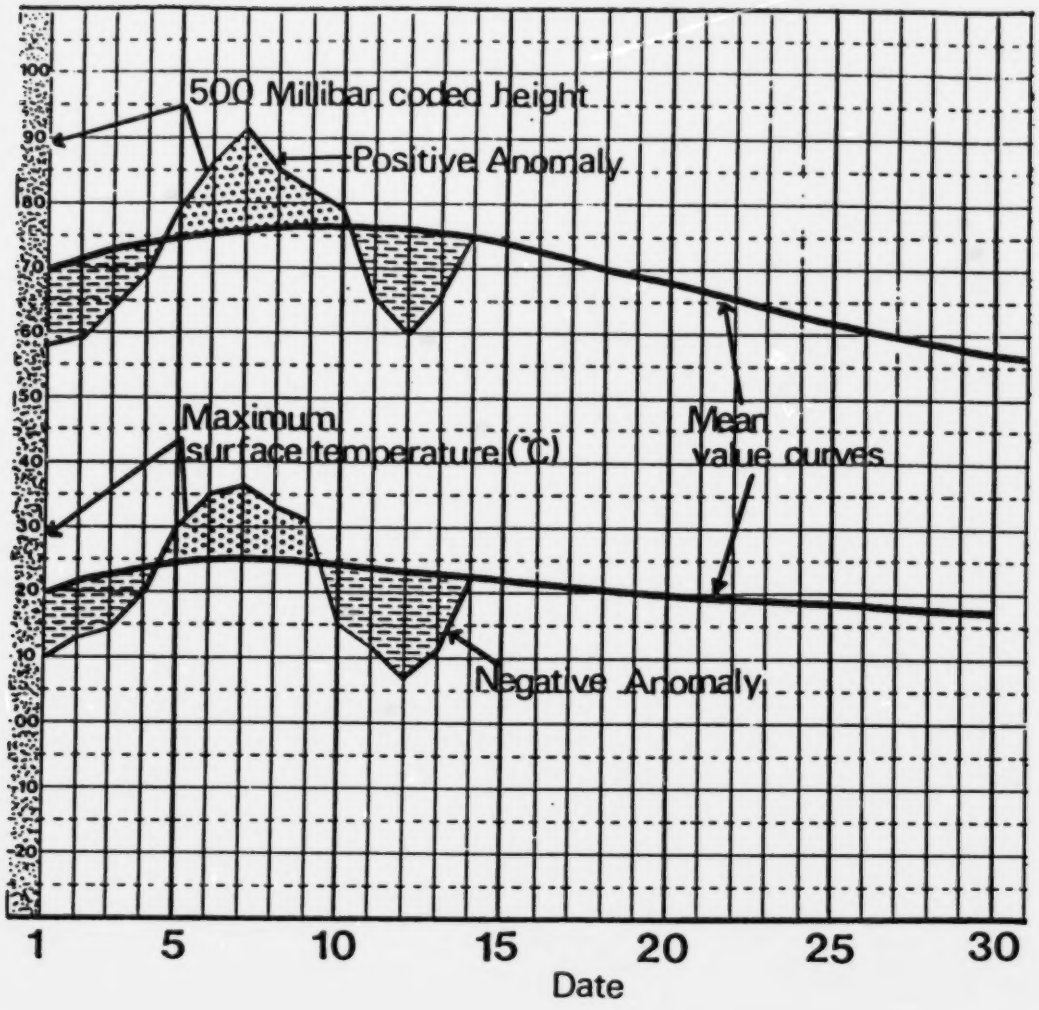

Fig. 1 Example of 500 Millibar and Maximum Surface Temperature Anomaly Chart.

Fig. 2 Locations of Major 1981 Fires in Alberta. Areas depicted not to scale.

observed to remain semi-stationary over an area for as long as 10 to 30 days. Frequently referred to as a "blocking high", the semi-stationary upper ridge usually gives a prolonged period of warm, dry weather resulting in rapid build-up and increased fuel flammability.

3. CHRONOLOGY OF THE ALBERTA 1981 FIRE SEASON

3.1 The Winter of 1980/81 and 1981 Spring Fire Season

The Alberta winter of 1981 was among the mildest on record (Canadian Weather Review, 1980-81). Precipitation amounts which had fallen consistently below normal values in the forest lands north of 54° North latitude during 1980 maintained this deficit trend through the winter of 1981. In January, temperatures departed as much as 12 - 14°C above normal in the Footner and Athabasca forests while precipitation amounts reached only 30 - 50% of mean values. Similarly dry conditions persisted through the month of March. However, April saw some precipitation relief in northern Alberta with High Level receiving 264% of the normal precipitation and Fort McMurray 141%. The above normal rainfall and cool temperatures in April reduced fire danger in the northern half of the province during the early stages of the fire season.

Dry weather returned to northern Alberta in May. Precipitation amounts reached only 30 - 35% of the normal accompanied by temperatures 2 - 3°C above normal. The Athabasca districts were subjected to particularly low relative humidities (20 - 25%) during most of the month. Little fire activity occurred, however, as the number of on-going fires remained below 20 throughout the month and only 2 000 ha burned over. The majority of the May fires were man-caused.

June saw a cooler, damper fire-weather regime develop over most of the province. Higher humidities overall and above normal precipitation in northwestern Alberta led to moderate fire danger levels through most of the month. A higher frequency of lightning ignition was observed in June but shower precipitation and high humidities suppressed fire spread to a large extent.

3.2 July

As the fire season entered July, the total provincial area burned stood at 8 800 ha. The month began with the building of an upper ridge which triggered a marked increase in fire danger throughout the province, particularly in northern Alberta. The 500 MB height and surface temperature anomalies were strongly in phase during the month (Fig. 3). The ridge was weakened July 3 as an upper trough and surface low moved across the northern half of Alberta. Scattered wet thunderstorms and strong winds accompanied the passage of the low, resulting in the first major fire run of the 1981 season. Nearly 20 000 ha were burned over on July 4 (Fig. 4). The ridge had completely broken down by July 6 and most forest districts settled into a cool and humid period. Precipitation amounts, however, were light and spotty.

A weak and brief recovery of the ridge pattern occurred July 11 to 13. The combination of lingering cool air aloft and warmer surface temperatures induced wet thunderstorm activity and a large number of lightning fire starts (Fig. 5). The generally low to moderate fire-danger levels and thunderstorm precipitation inhibited any appreciable spread of the new fire starts. A more pronounced recovery of the ridge developed between July 17 and 20. Again the recovery was brief as another rapidly moving upper trough pushed the ridge eastward and produced numerous lightning fire starts on July 19. Precipitation accompanied most strikes and continuing moderate fire-danger levels aided suppression action in keeping area burned to a minimum. The remainder of July saw little fire activity and no extremes of temperature, lightning incidence or fire danger.

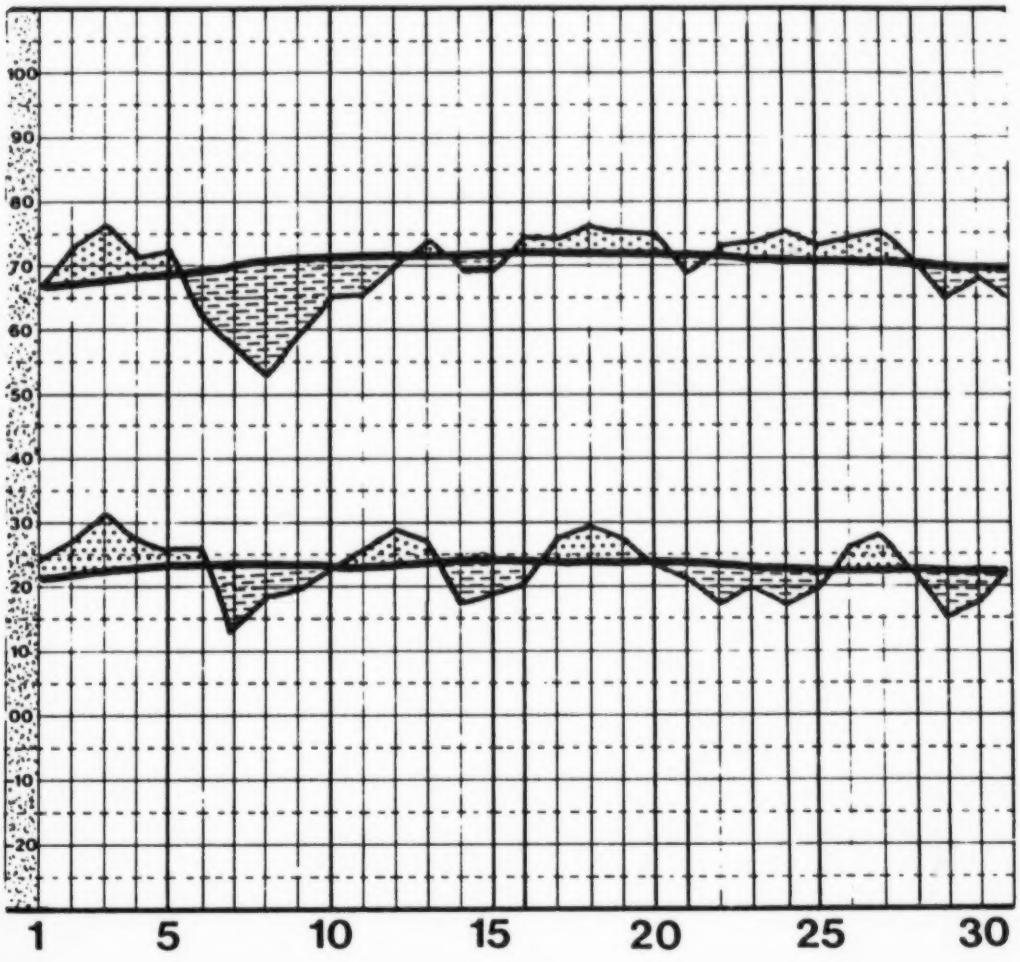

Fig. 3 July Anomalies.

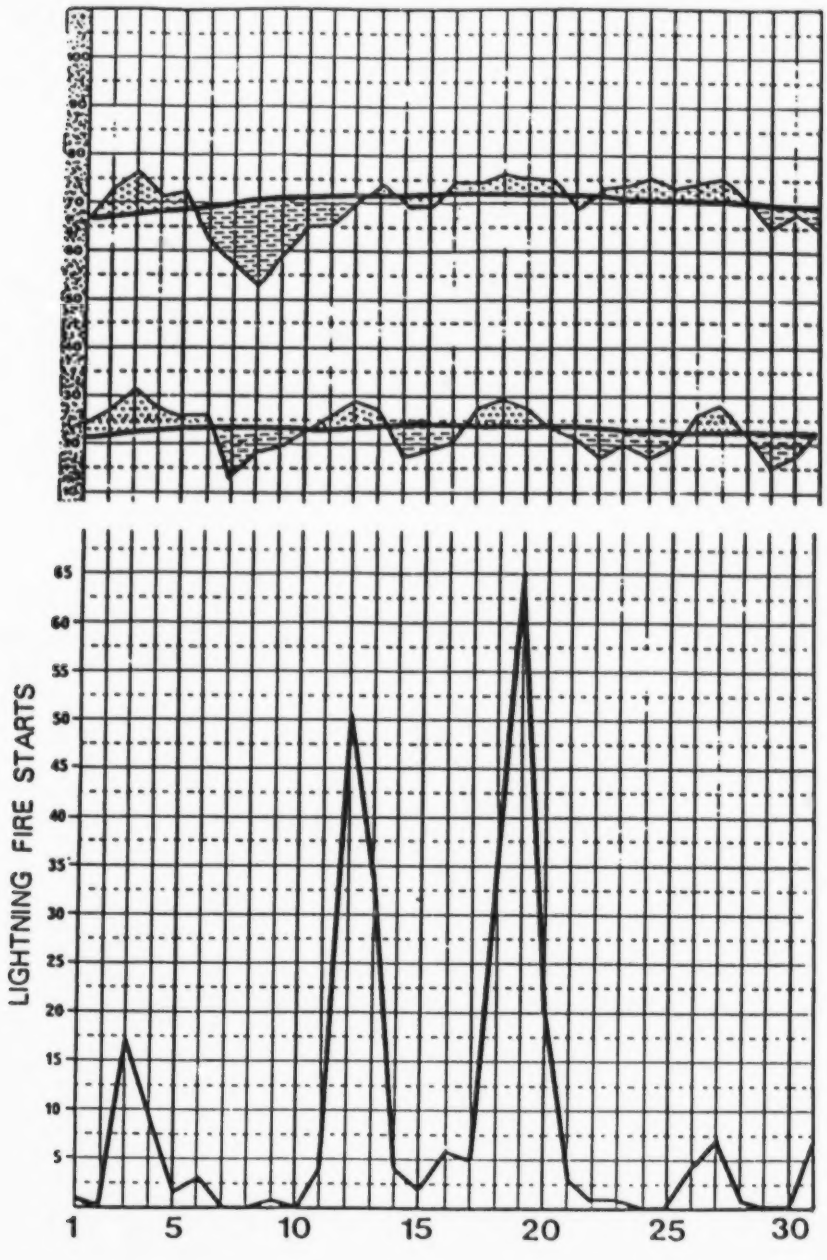

Fig. 4 July Daily Lightning Fire Starts and Anomalies.

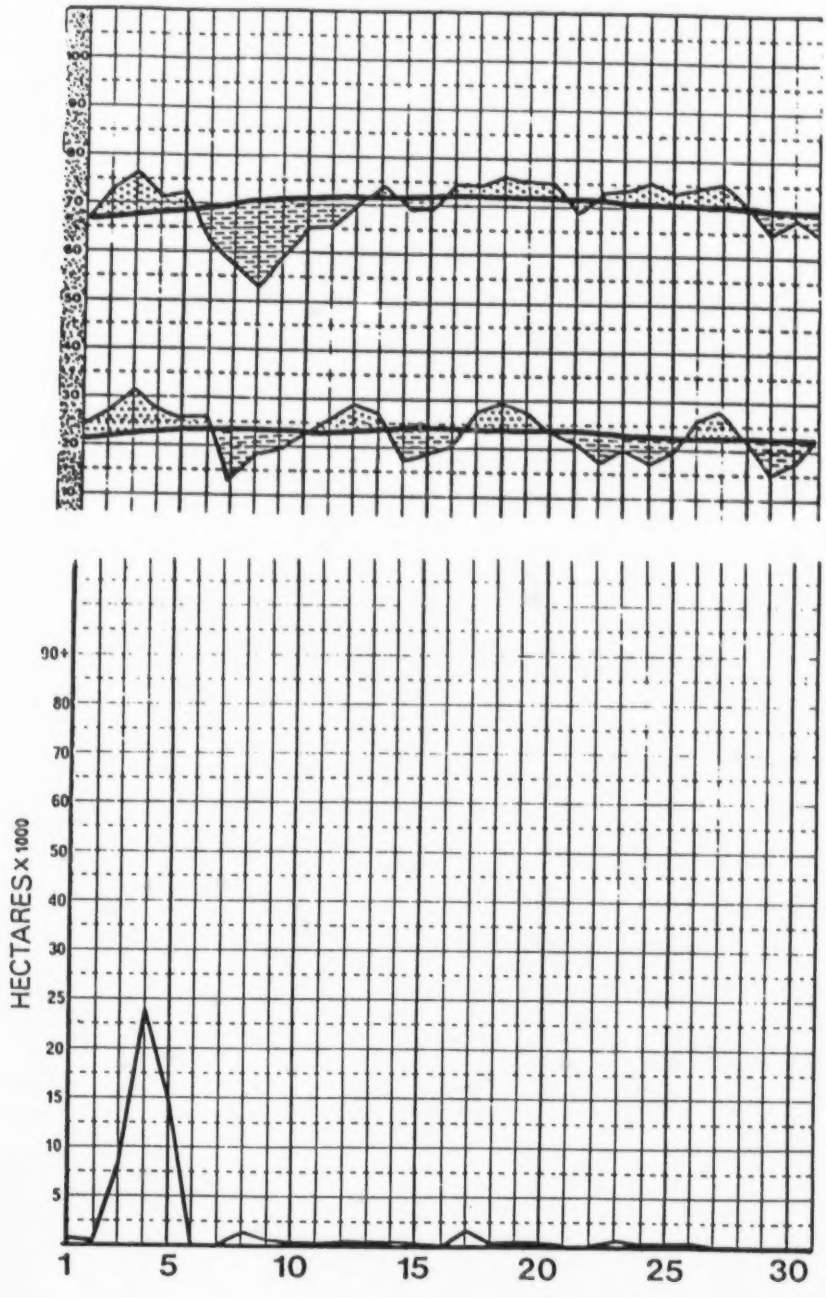

Fig. 5 July Daily Burned Area and Anomalies.

3.3 August: The Fire Season Continues

When July has come and gone in Alberta, people in the fire control business traditionally look for the beginning of the end of the fire season. Unfortunately, the weather frequently ignores tradition and did so in August, 1981. A blocking high began to build over the province on August 4 and remained firmly entrenched, as indicated by a strongly positive 500 MB height anomaly, until August 28 (Fig. 6). Maximum temperatures of 35°C, relative humidities of 25%, light winds and stable atmospheric conditions were general throughout the province during August 3 to 11. Fire danger indices in the northern half of Alberta peaked well into the extreme categories.

The period of August 10 to 20 deserves close scrutiny. Although the 500 MB anomaly remained positive, indicating the ridge was essentially stationary, a series of significant dips (e.g., August 13 and 21) are observed in the ridge pattern. These dips are indicative of the ridge being temporarily weakened and are the result of rapidly moving "short waves" or upper troughs of synoptically small scale. Cooling aloft often accompanies short waves as they travel around the outer perimeter of the blocking ridge. Little or no cooling occurs at the surface, however, resulting in airmass thunderstorms along the path of the short wave. Due to the dry condition of the surface, atmosphere and fuels brought about by the ridge, these thunderstorms may produce only sparse amounts of precipitation and readily lead to new fire starts. August 10 to 20 witnessed a series of fast-moving short waves travel through northern Alberta. The region was inundated with 165 lightning fire starts during this 11-day period (Fig. 7). A number of these new fire starts were destined to become among the largest conflagrations of 1981. This rash of new fires in mid-August placed enormous pressure on hard-pressed fire-control personnel battling six out-of-control blazes totalling 52 000 ha.

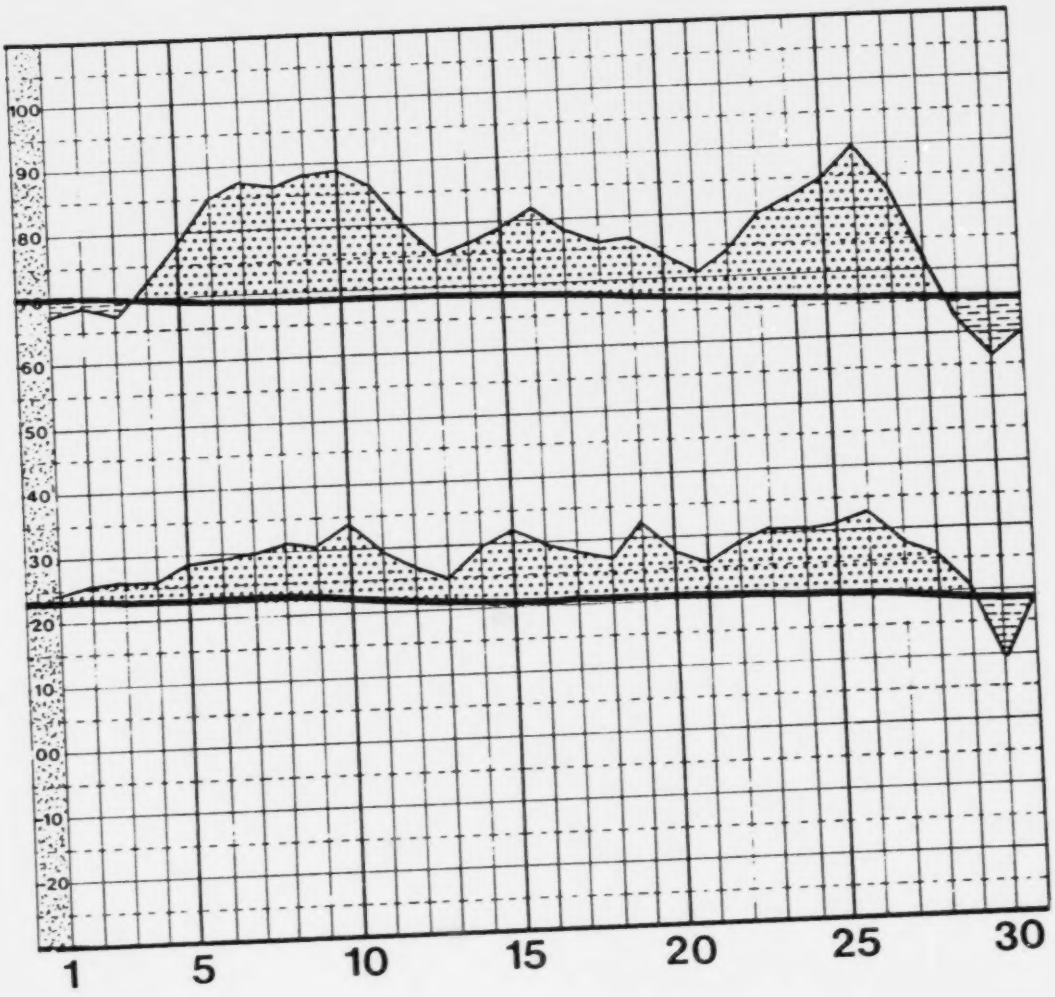

Fig. 6 August Anomalies

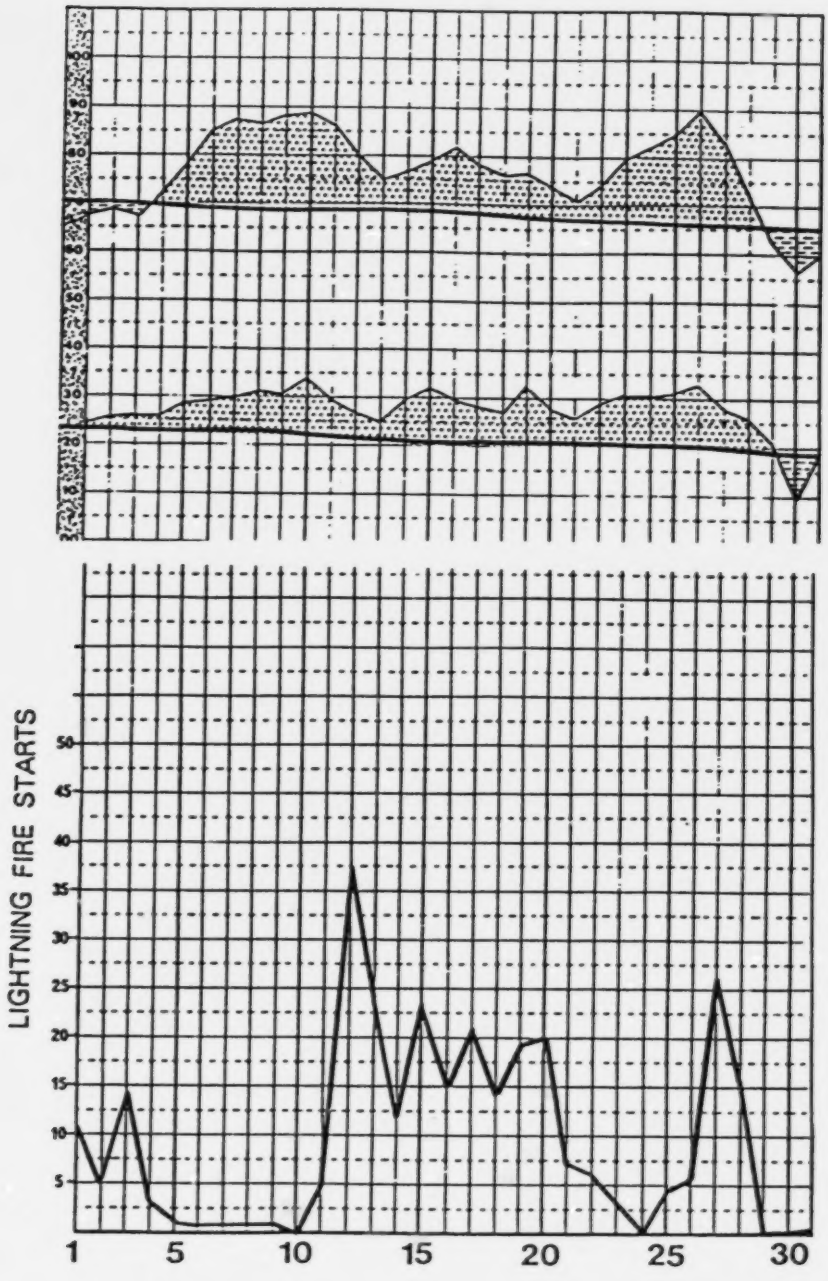

Fig. 7 August Daily Lightning Fire Starts and Anomalies

The upper ridge began to recover toward a second pronounced peak on August 22. Temperatures again reached the 30 - 35°C range at the apex of the ridge on August 26. Going fires were active during this period with 120 000 ha burned over (Fig. 8). By the evening of August 26 a major shift in the synoptic pattern began to develop. For several days an upper low had lurked off the coast of Vancouver Island. Ominously, this system finally began to push inland. The breakdown of the ridge was imminent.

3.3.1 Detailed Account of the August Ridge Breakdown

3.3.1.1 August 26

At 500 MB the blocking ridge pattern was clearly evident (Fig. 9), extending from the central United States to the Canadian Plains and north into the Yukon. The ridge was bounded by an upper low over the Great Lakes and a more intense system near Vancouver Island. The west coast low had previously been anchored in the Gulf of Alaska; the development of a blocking ridge over western Canada usually requires the positioning of a well-defined upper trough or low in the Gulf. Upper lows which are eventually situated near the lower British Columbia mainland seldom remain stationary and generally move southeastward into the Pacific northwest region of the United States or northeasterly toward higher latitudes.

On the surface map (Fig. 10) the broad high pressure area associated with the upper ridge dominated the weather across the Prairies. A parching southeasterly surface flow gave temperatures of 30 - 35°C, relative humidities below 30% and severe burning conditions throughout the Footner Lake and Athabasca forests. A weak surface low and frontal wave formed near Peace River by early morning. Cool air began to accumulate under a surface high pressure system in British Columbia and edged into western Alberta.

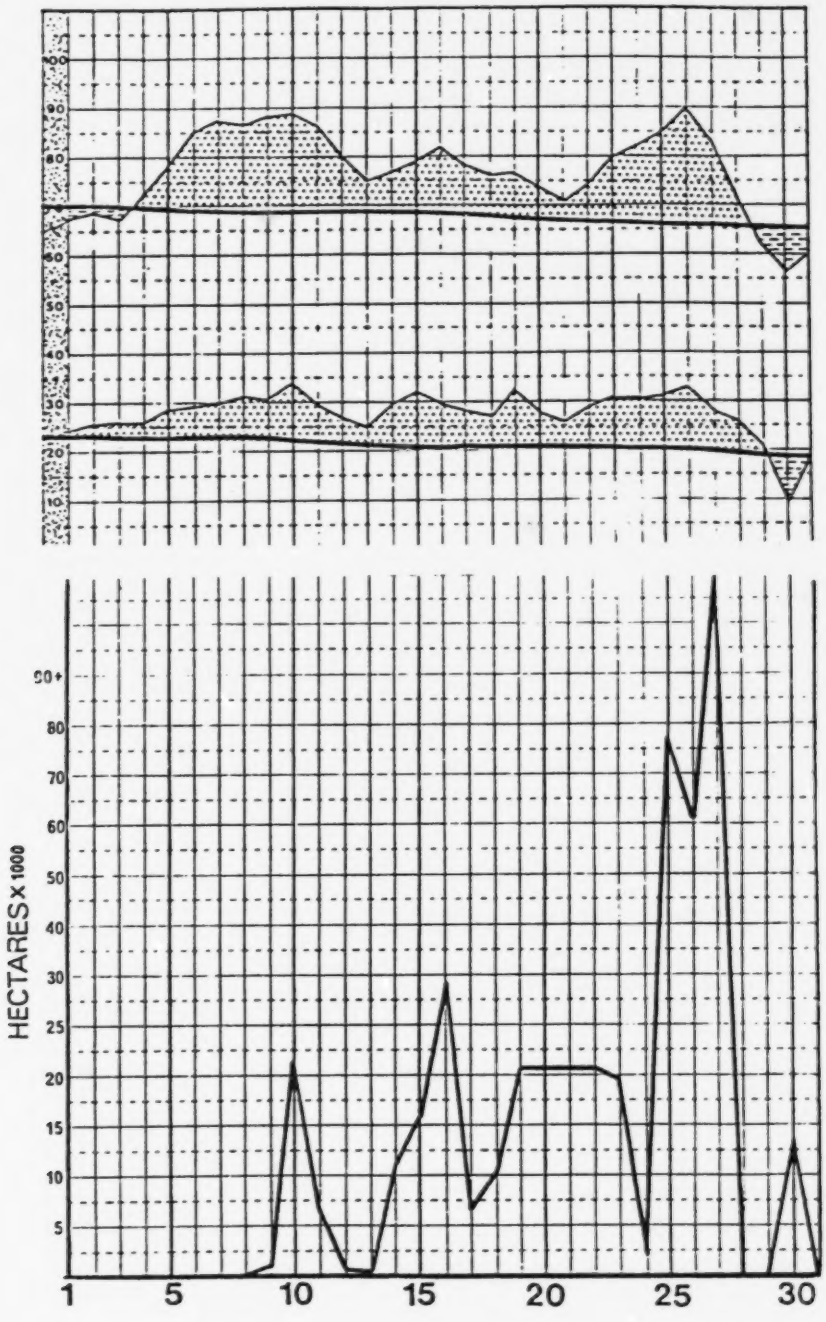

Fig. 8 August Daily Burned Area and Anomalies.

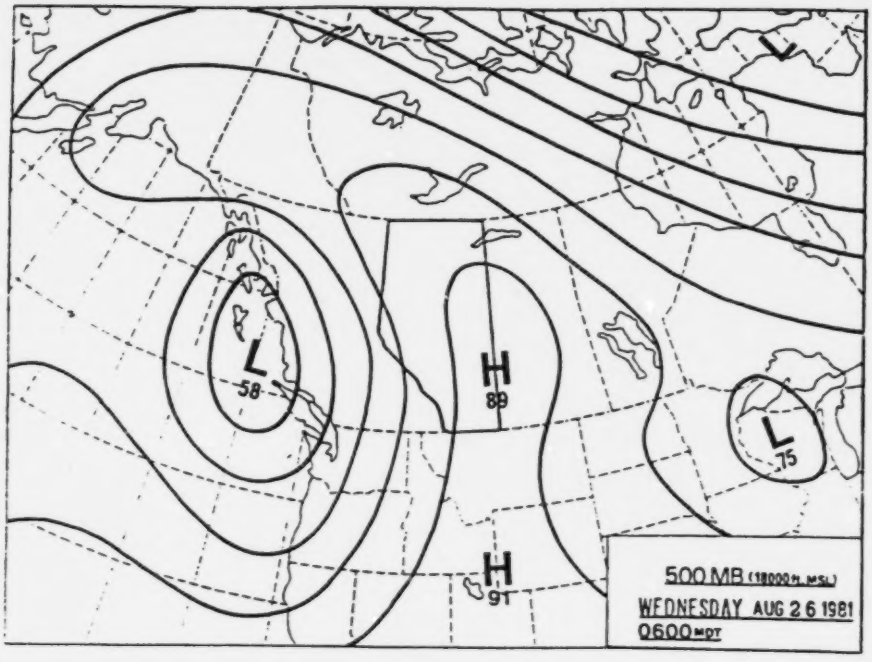

Fig. 9 500 MB Chart: 0600 MDT August 26, 1981.

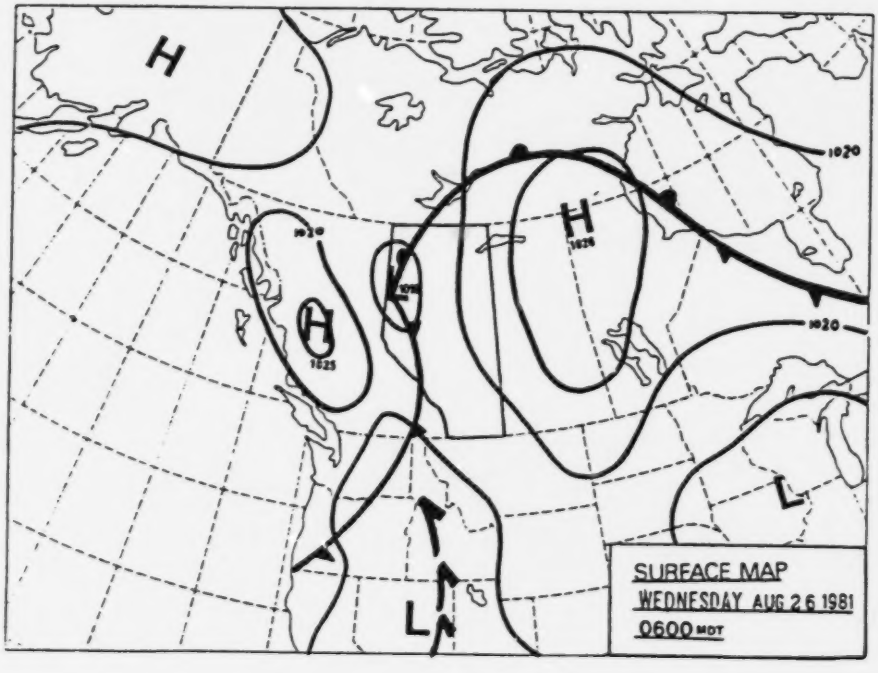

Fig. 10 Surface Weather Chart: 0600 MDT August 26, 1981.

3.3.1.2 August 27 "Black Thursday".

The Pacific upper low made its move on the morning of August 27. The system took a northeasterly track through central British Columbia toward Alberta (Fig. 11), pushing the ridge eastward into Saskatchewan and Manitoba. This movement of the low split the ridge in its northern extremity, causing the formation of a closed upper high in the Yukon.

The 0600 MDT surface map for August 27 (Fig. 12) showed a marked intensification of the low and frontal wave which had developed near Peace River the previous day. The low remained essentially stationary but had deepened by eight millibars during the 24 hours since its formation. The cold front displayed little eastward movement from its position on August 26. As the going fires in Footner Lake and Athabasca forests were situated in the warm sector of the low, a predominantly east to southeasterly surface flow of 15 km/h was present on the morning of August 27. Pressure gradients across the northern half of the province progressively tightened as afternoon approached and the low continued to deepen.

By early afternoon the fire-weather situation had become extremely critical. The surface low tracked retrogressively to lie near High Level at 1200 MDT (Fig. 13) as the upper low approached from British Columbia. Explosive burning conditions were established in the fire areas of northern Alberta by early afternoon. The resulting violent fire behavior created havoc with existing suppression operations. Tables 1 to 3 present fire danger and weather conditions preceding and during "Black Thursday". The severe fire weather plagued the going fires until 2000 MDT that evening. Undocumented reports from the fire areas in Footner Lake Forest indicated that wind speeds peaked beween 1700 and 2000 h. Fire-line personnel estimated wind gusts attained speeds of 65 to 80 km/h during the period of 1700 to 2000 h. The strong gusts followed in the wake of a cold front which passed through High Level near 1700 h. The winds recorded at the High Level AFS synoptic station (Table 3) appear to substantiate these reports. Extensive thunderstorm activity led to 42 fire starts through-

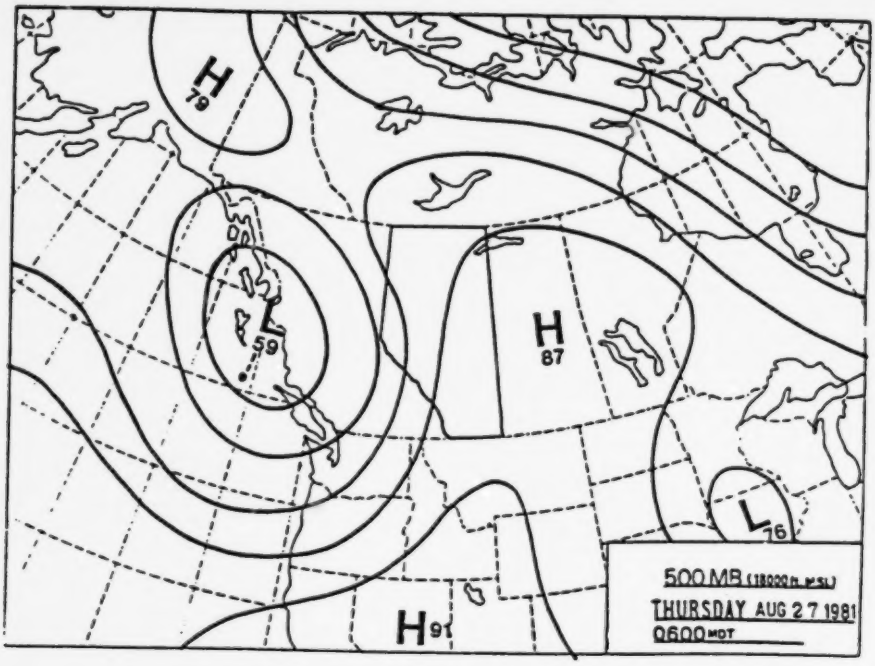

Fig. 11 500 MB Chart: 0600 MDT August 27, 1981.

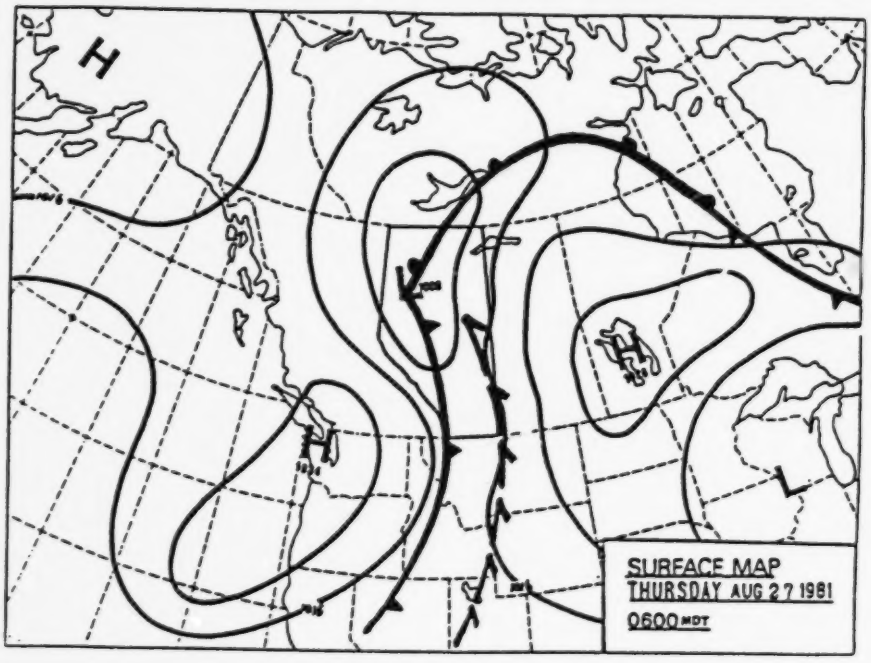

Fig. 12 Surface Weather Chart: 0600 MDT August 27, 1981.

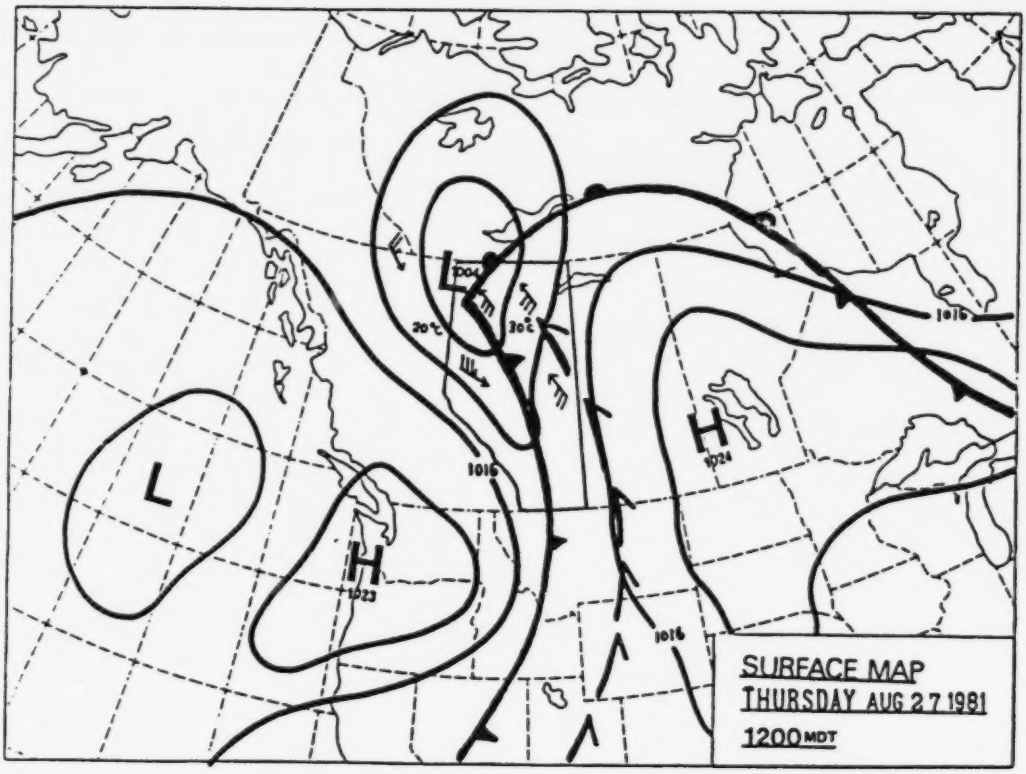

Fig. 13 Surface Weather Chart: 1200 MDT August 27, 1981

TABLE 1

Mean Values and Deviations of the Build-up Index and Fine Fuel Moisture Code in the Footner Lake and Athabasca Forests August, 1981

FOOTNER LAKE FOREST

Date	Mean BUI (S.D.)	Mean FFMC (S.D.)	Date	Mean BUI (S.D.)	Mean FFMC (S.D.)
1	36 (16.0)	77 (11.7)	14	67 (17.2)	88 (1.7)
2	32 (16.7)	72 (13.2)	15	69 (17.0)	87 (2.7)
3	38 (17.8)	84 (4.6)	16	73 (16.9)	90 (1.5)
4	42 (18.8)	85 (4.1)	17	77 (16.5)	91 (1.2)
5	39 (17.7)	83 (8.1)	18	79 (17.8)	89 (0.8)
6	43 (17.3)	87 (2.6)	19	76 (19.9)	88 (0.8)
7	48 (17.3)	90 (1.7)	20	79 (21.0)	90 (1.3)
8	52 (13.8)	92 (1.8)	21	84 (22.2)	91 (1.4)
9	57 (13.8)	93 (1.6)	22	89 (22.6)	91 (1.6)
10	62 (14.1)	93 (1.4)	23	89 (21.8)	91 (1.0)
11	65 (13.8)	92 (1.2)	24	90 (18.4)	90 (1.1)
12	50 (13.4)	73 (13.4)	25	98 (22.3)	89 (1.3)
13	62 (17.4)	84 (7.3)	26	102 (22.4)	89 (1.2)

ATHABASCA FOREST

Date	Mean BUI (S.D.)	Mean FFMC (S.D.)	Date	Mean BUI (S.D.)	Mean FFMC (S.D.)
1	46 (16.3)	87 (1.4)	14	72 (20.9)	88 (2.3)
2	33 (13.3)	59 (13.0)	15	75 (20.5)	90 (1.0)
3	34 (14.4)	76 (6.3)	16	80 (19.8)	90 (1.6)
4	36 (15.6)	80 (4.7)	17	78 (16.2)	91 (0.3)
5	39 (16.3)	86 (5.7)	18	86 (20.6)	88 (1.2)
6	39 (13.3)	88 (1.5)	19	85 (20.6)	88 (2.2)
7	49 (16.4)	90 (1.9)	20	89 (21.1)	88 (2.1)
8	53 (16.7)	92 (0.5)	21	88 (15.4)	90 (1.7)
9	60 (15.7)	93 (0.9)	22	88 (16.2)	90 (1.5)
10	65 (17.1)	93 (0.8)	23	92 (16.2)	91 (0.7)
11	65 (12.4)	92 (0.7)	24	98 (16.7)	91 (0.5)
12	66 (20.2)	85 (8.2)	25	100 (16.9)	90 (0.6)
13	68 (19.1)	86 (5.2)	26	104 (16.0)	90 (1.4)

SOURCE: Alberta Forest Service fire-weather records.
(See Table 2 for individual station identification.)

NOTE: Abbreviations used: BUI = Build-up Index
FFMC = Fine Fuel Moisture Code
S.D. = Standard Deviation

TABLE 2

Fire Weather Observations from AFS Lookouts and Ranger Stations in Northern Alberta 1300 MDT August 27, 1981

Forest	Station	Elevation (m)(ASL)	Temp.(°C)	RH(%)	Windspeed (Gust)(Km/h)	FFMC	ISI	BUI	FWI
FOOTHILLS	Buffalo	790	23	44	40(62)	91	36	105	73
	Wadlin	790	23	50	35(50)	89	21	103	56
	LaCrete	304	28	37	26	92	20	143	56
	Ponton	882	28	30	25(45)	92	19	75	42
	Whtsnds	942	26	42	35	89	21	94	39
	Foggy	882	26	48	20(32)	89	10	98	32
	Amber	578	25	61	11	88	6	79	20
	Adair	365	29	46	10(30)	90	6	117	24
ATHABASCA	Buckton	848	27	38	30	92	25	110	60
	Birch Mt	806	28	36	22(45)	92	17	83	42
	Edra	800	27	38	28(45)	92	23	105	55
	Legend	833	26	50	26(46)	90	16	108	44
	Ellis	550	28	45	20(35)	90	12	117	34
	Ft McKay	234	30	42	15	90	9	140	33
	Jean Lks	763	25	45	22(35)	91	15	100	46
	Muskeg	638	28	33	28(40)	92	23	97	53

SOURCE: Alberta Forest Service Weather Section

NOTE: Abbreviations used:

Stn.	=	Station
Temp.	=	Temperature
RH	=	Relative Humidity
Km/h	=	Kilometres per hour
FFMC	=	Fine Fuel Moisture Code
ISI	=	Initial Spread Index
BUI	=	Build-up Index
FWI	=	Fire Weather Index

All wind directions in above observations from the south to southeast.

TABLE 3

Surface Weather Observations from AES Stations

August 27, 1981

Station	Time (MDT)	Temperature (°C)	RH (%)	Windspeed (Gust) (Km/h)
	1400	29	36	SE 19 (34)
	1500	28	41	SE 19 (36)
High	1600	26	46	SE 19 (34)
Level	1700	25	43	SW 19 (39)
Airport[a]	1800	23	50	SW 21 (47)
	1900	21	43	SW 26 (43)
	2000	20	43	SW 17
	2100	16	55	SW 6
	1400	32	29	SE 19 (30)
	1500	32	27	SE 26 (41)
Fort	1600	31	31	SE 24 (32)
McMurray	1700	30	34	SE 23
Airport[b]	1800	29	36	SE 24 (36)
	1900	27	36	SE 17
	2000	25	37	S 21
	2100	22	40	S 11

SOURCE: AES observation stations at High Level and Fort McMurray airports.

NOTE: Abbreviation used: RH = relative humidity

[a]Station elevation = 334 m ASL
[b]Station elevation = 368 m ASL

out the province. Fortunately, cool, moist air spread into Alberta by nightfall. The westerly winds behind the front diminished overnight as the cold front moved into Saskatchewan.

The grim aftermath revealed six burnt-out fire camps and 376 000 ha of burned forest land. Although the SITREPS imply that only 166 000 ha were burned over on August 27 and an additional 210 000 ha on August 28, weather evidence and observed fire behavior indicate virtually all 376 000 ha burned on August 27. The disproportionately high figure appearing on the SITREP for August 28 is likely the reflection of a more accurate assessment of the area burned on "Black Thursday".

3.3.1.3 August 28.

By Friday morning, the ridge that dominated the weather through most of August had completely broken down (Fig. 14). An upper low developed over northern Alberta while the surface low had taken a northeasterly course overnight and was located near Great Slave Lake by 0600 MDT on August 28 (Fig. 15). A cool, westerly flow brought temperatures of 17 - 19°C, relative humidities in the 45 - 55% range and surface winds of 15 - 20 km/h to the fire areas. Unfortunately, no effective precipitation relief occurred during or within 24 hours of the ridge breakdown.

The final three days of August stood in stark contrast to the 28 days that preceded them. Cold arctic air slumped southward into northern Alberta under the upper trough bringing below freezing temperatures to the Footner Lake and Athabasca forests on August 29 and 30. Light snow fell in Footner Lake forest during the evening of August 29. Some stations in the Footner Lake districts recorded precipitation amounts up to 12.0 mm between August 28 to 30; however, most received only 0.5 to 2.0 mm. No significant precipitation occurred elsewhere in the province.

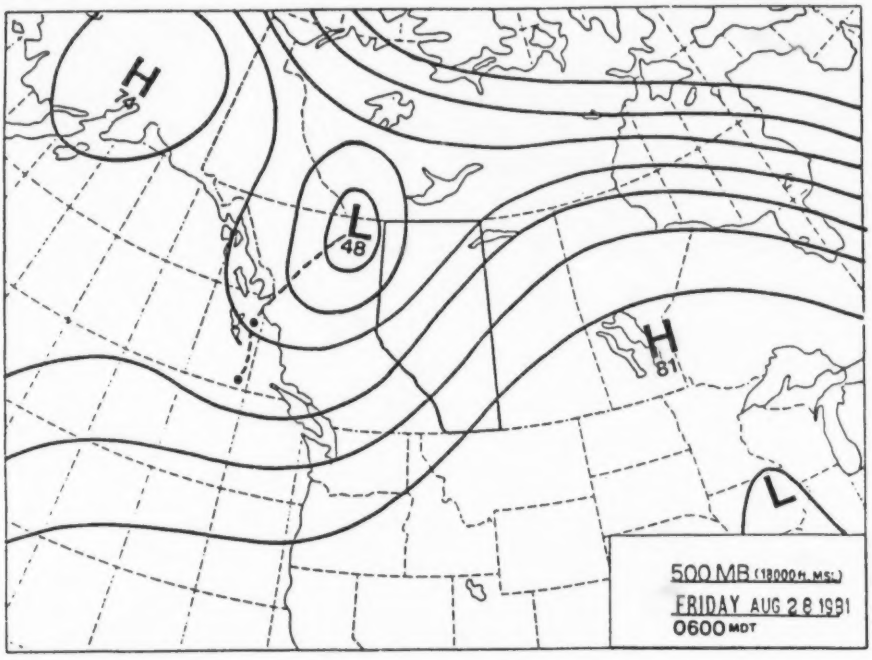

Fig. 14 500 MB Chart: 0600 MDT August 28, 1981.

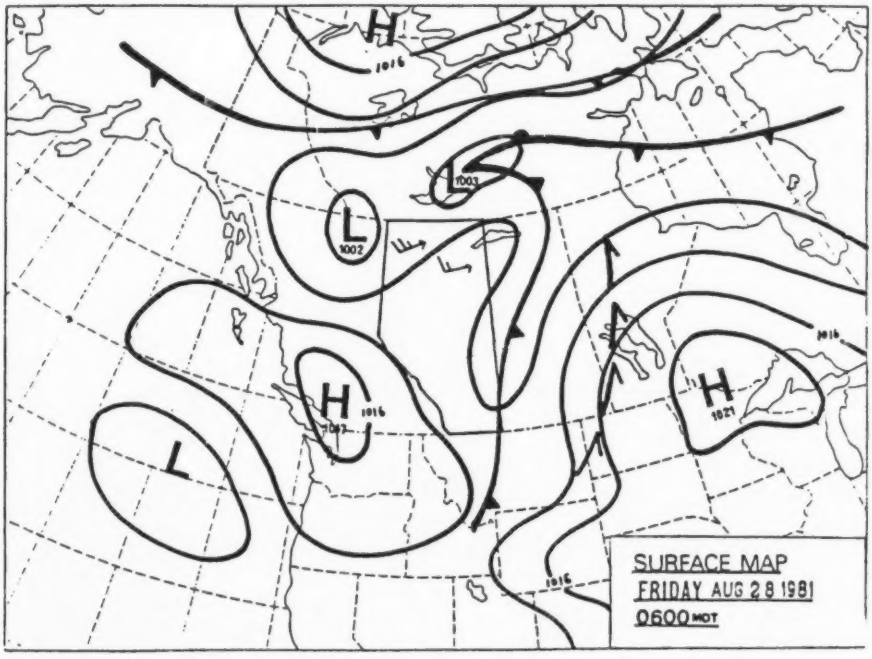

Fig. 15 Surface Weather Chart: 0600 MDT August 28, 1981.

3.3.1.4 Comparison of August 27 Fire-Weather and the Byram Conditions.

Byram (1954) identified a number of fuel and weather factors associated with blow-up wildfires. These factors were:

1. An abundant, dry fuel supply;
2. Unstable atmospheric conditions;
3. A windspeed of 29 km/h or higher at an elevation equal or slightly greater than that of the fire;
4. Vertical wind profile showing an increase in windspeed 1 000 to 1 500 m above the fire and then decreasing above that level.

The forest fuels on August 27, 1981, were clearly dry and abundant as Build-up Index (BUI) and Fine Fuel Moisture Code (FFMC) values in Tables 1 and 2 show. Radiosonde soundings from Fort Nelson and Fort Smith (Fig. 16) taken at 0600 MDT, August 27, indicated a moderate degree of potential instability was present in the fire areas of northern Alberta. Several lookout observations from the fire areas also reported surface wind speeds near or in excess of 30 km/h (Table 2) with most recording significantly higher gusts in the 50 - 60 km/h range at 1300 MDT. Pilot balloon (pibal) measurements from the Slave Lake airport (Fig. 17) at 0600 MDT and Fort McMurray airport (Fig. 18) at 1200 MDT both showed wind speed profiles of increasing speed with height in the first 1 000 to 2 000 m above ground. The Fort McMurray 1200 h pibal had begun to display a Byram profile.

The Footner Lake fires exhibited their most extreme behavior between 1700 to 1900 h shortly prior and subsequent to a cold frontal passage. Witnesses on the fire line estimated peak gusts reached 80 km/h from the west-southwest. Fires in the Athabasca forest were also observed to increase their rate of spread and intensity during this period.

The Slave Lake 1800 h pibal (Fig. 19) depicted a well-developed low-level jet of 40 km/h at 1 000 m and a windshift to the northwest.

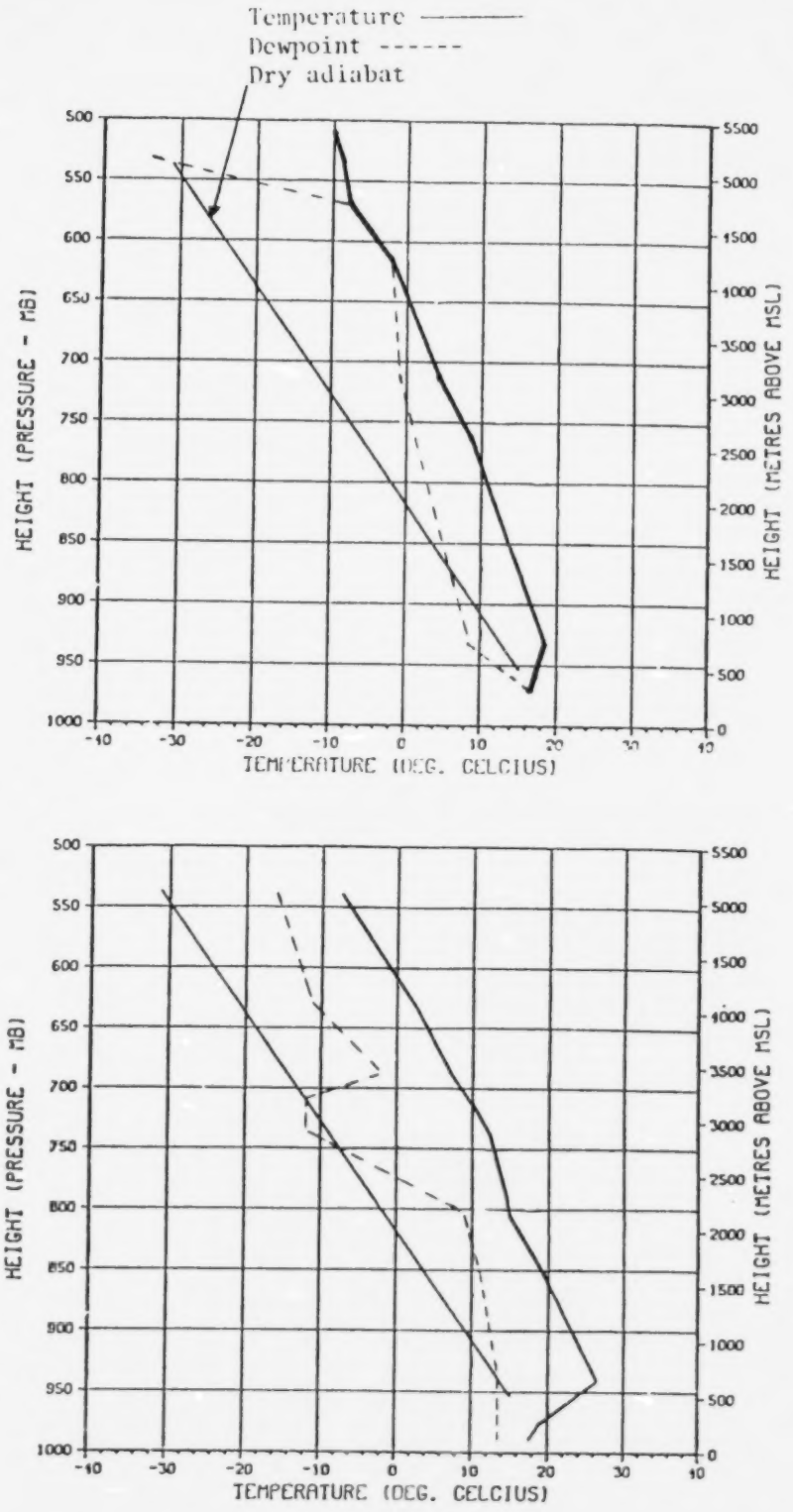

Fig. 16 Temperature and Dewpoint Profiles at Fort Nelson, British Columbia (top) and Fort Smith, Alberta (bottom):0600 MDT August 27, 1981

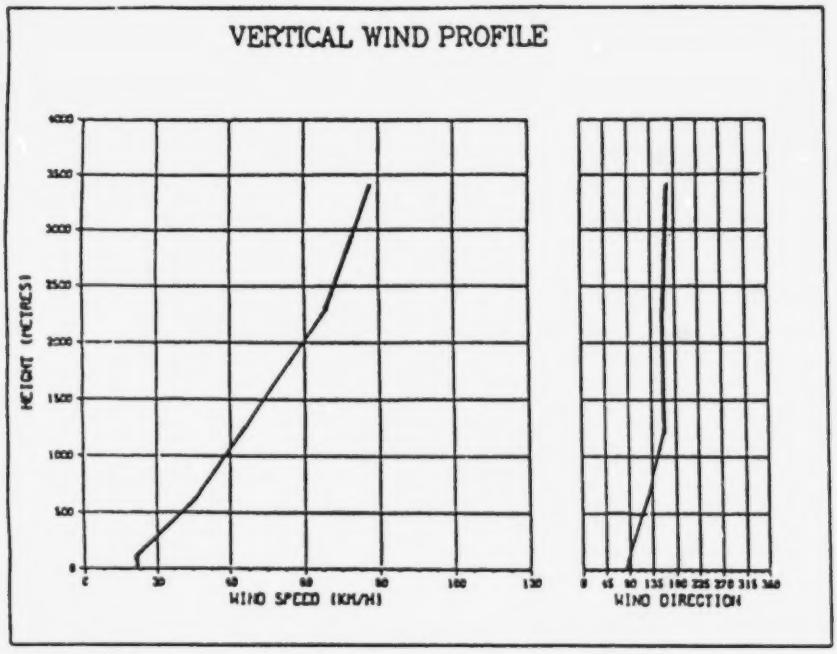

Fig. 17 Vertical Windspeed and Direction Profile at Slave Lake, Alberta 0600 MDT August 27, 1981

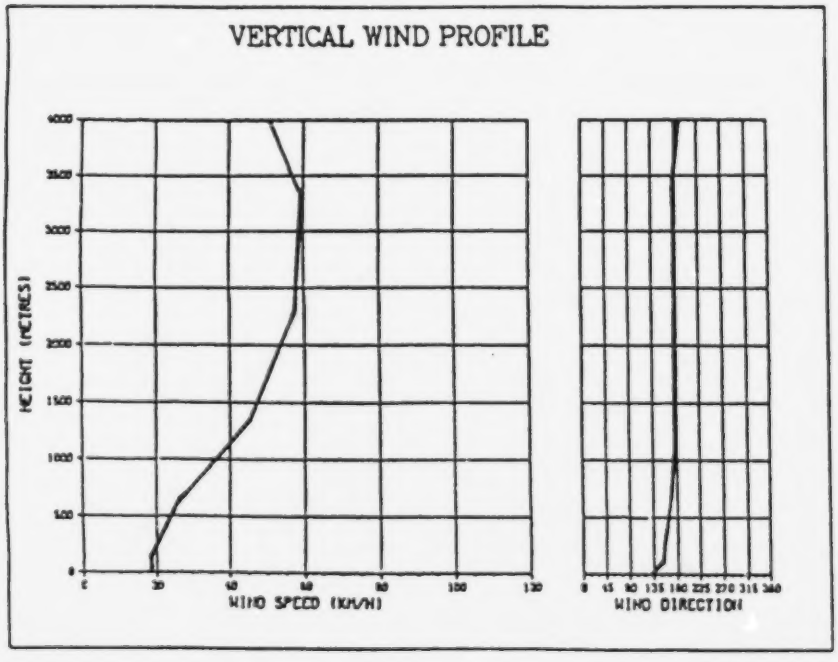

Fig. 18 Vertical Windspeed and Direction Profile at Fort McMurray, Alberta 1200 MDT August 27, 1981

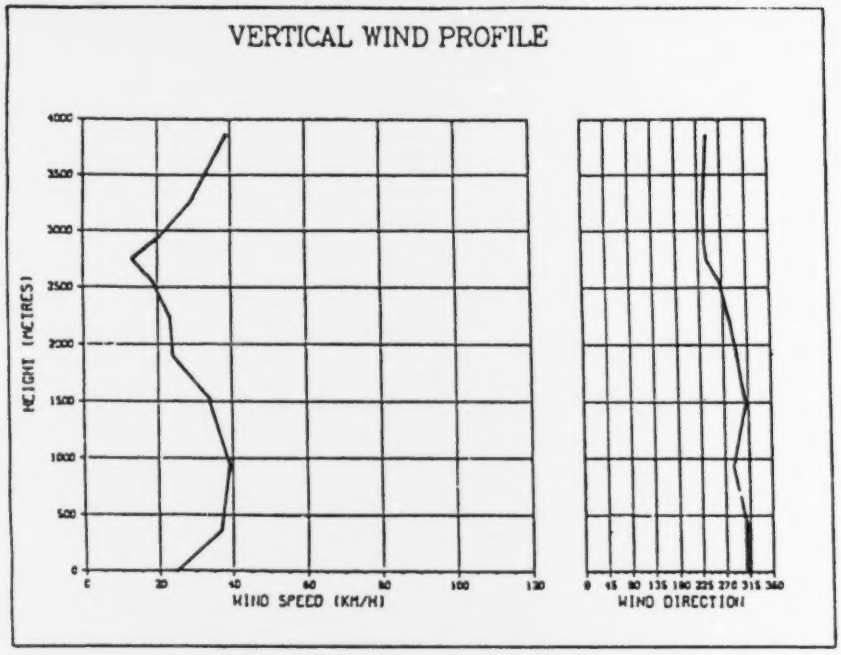

Fig. 19 Vertical Windspeed and Direction Profile at Slave Lake, Alberta 1800 MDT August 27, 1981.

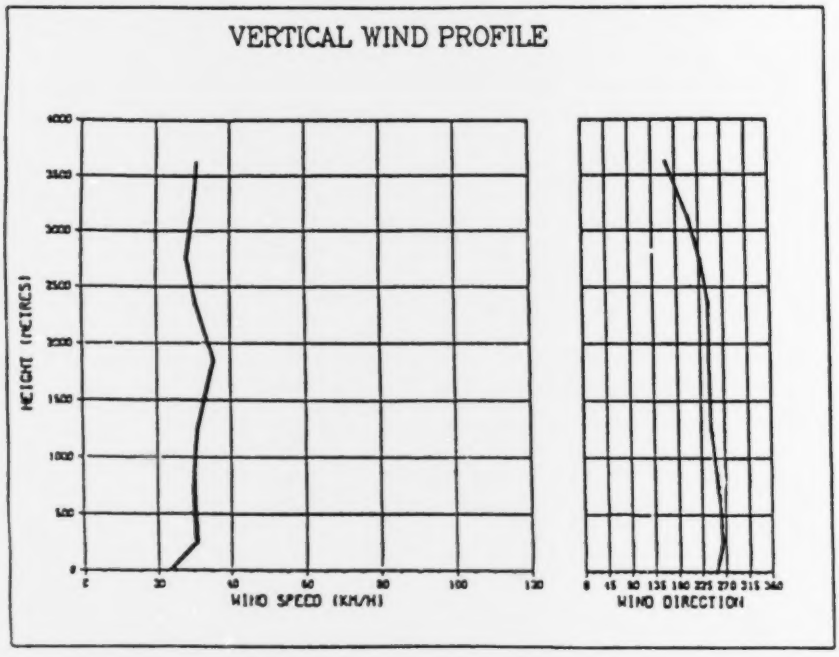

Fig. 20 Vertical Windspeed and Direction Profile at Fort McMurray, Alberta 1800 MDT August 27, 1981

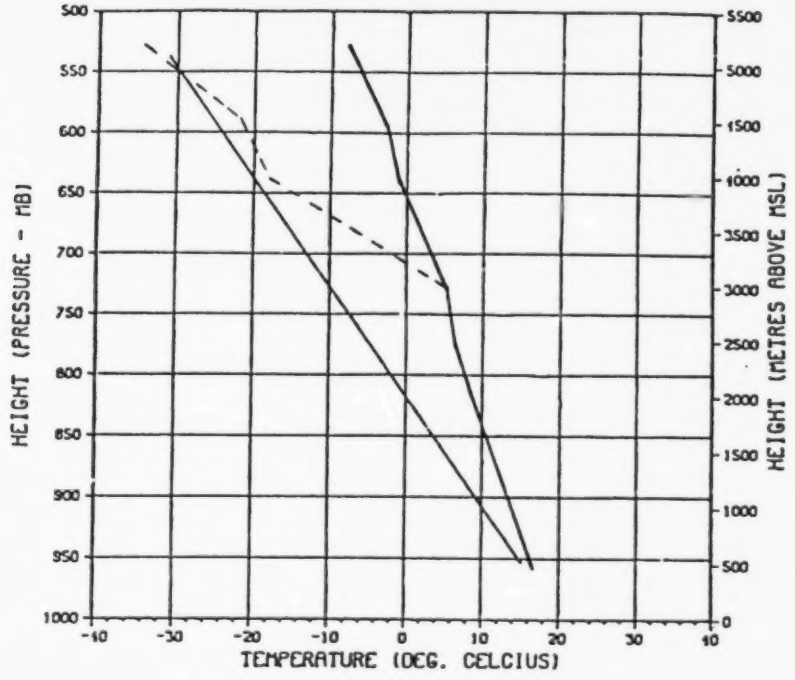

Fig. 21 Vertical Temperature and Dewpoint Profile at Fort Nelson, British Columbia: 1800 MDT August 27, 1981

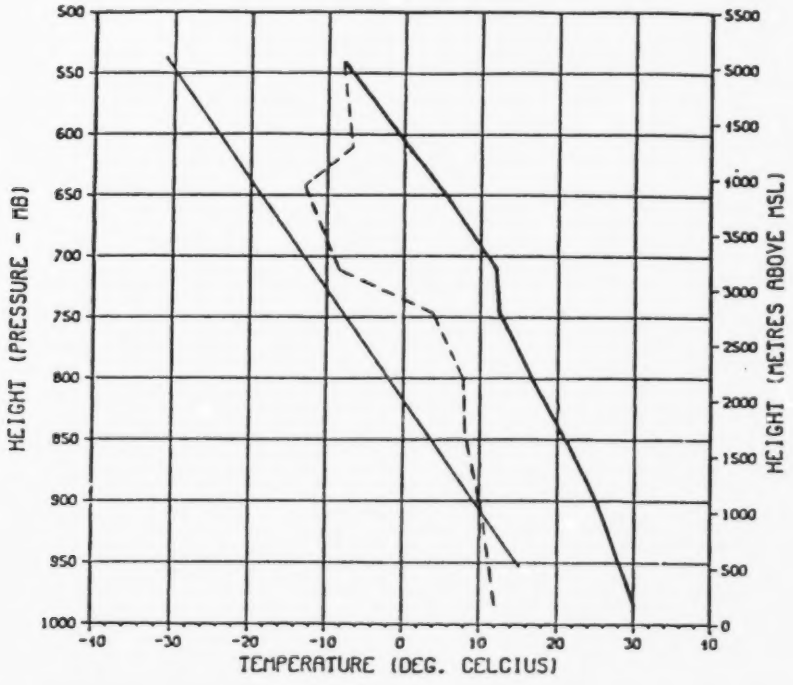

Fig. 22 Vertical Temperature and Dewpoint Profile at Fort Smith, Alberta: 1800 MDT August 27, 1981

This evidence strongly suggests the low-level jetting effects were present over the Footner fires at the time of extreme blow-up. The Fort McMurray 1800 h pibal (Fig. 20) did not display appreciable jetting characteristics. The 1800 h radiosonde sounding at Fort Nelson (Fig. 21) indicated a major change in airmass had occured, shown by a cooling of 4 - 8°C above 1 500 m MSL and saturation from the surface to 3 000 m MSL. Moderate rain was actually falling during the radiosonde ascent. Cooler, moister air moved eastward into the Footner Lake region by mid-evening. The Fort Smith 1800 h radiosonde (Fig. 22) showed that a very warm, dry and unstable atmosphere remained over the Athabasca fires well into the evening. The data indicates that the Byram conditions were generally met in the Footner Lake and Athabasca forests on August 27, 1981.

3.3.2 September - Shades of August

The cool, damp upper trough weather continued into the first week of September amid hopes the fire season had finally come to an end. Nature's timetable, however, had scheduled an extension of the fire season into mid-September. The return of the upper ridge (Fig. 23) and 30°C temperatures and low relative humidities again prompted very high to extreme fire danger in the stubbornly dry northern Alberta forests. On September 7, a rapidly moving upper trough advanced from the Gulf of Alaska into northern British Columbia. The trough spawned a series of surface lows, the first of which moved along the 60th parallel on September 8 and swept a weak cold front through northern Alberta. A more intense system soon followed as the upper trough approached Alberta on September 9. Southwesterly winds gusting to 50 km/h behind the cold front of this second system blew the northern fires through 76 000 ha over September 9 and 10 (Fig. 24). Light thundershowers occurred along the front but few new fires resulted (Fig. 25). The ridge had collapsed by the morning of September 10 and subsequently resulted in significant cooling but little precipitation in the fire areas.

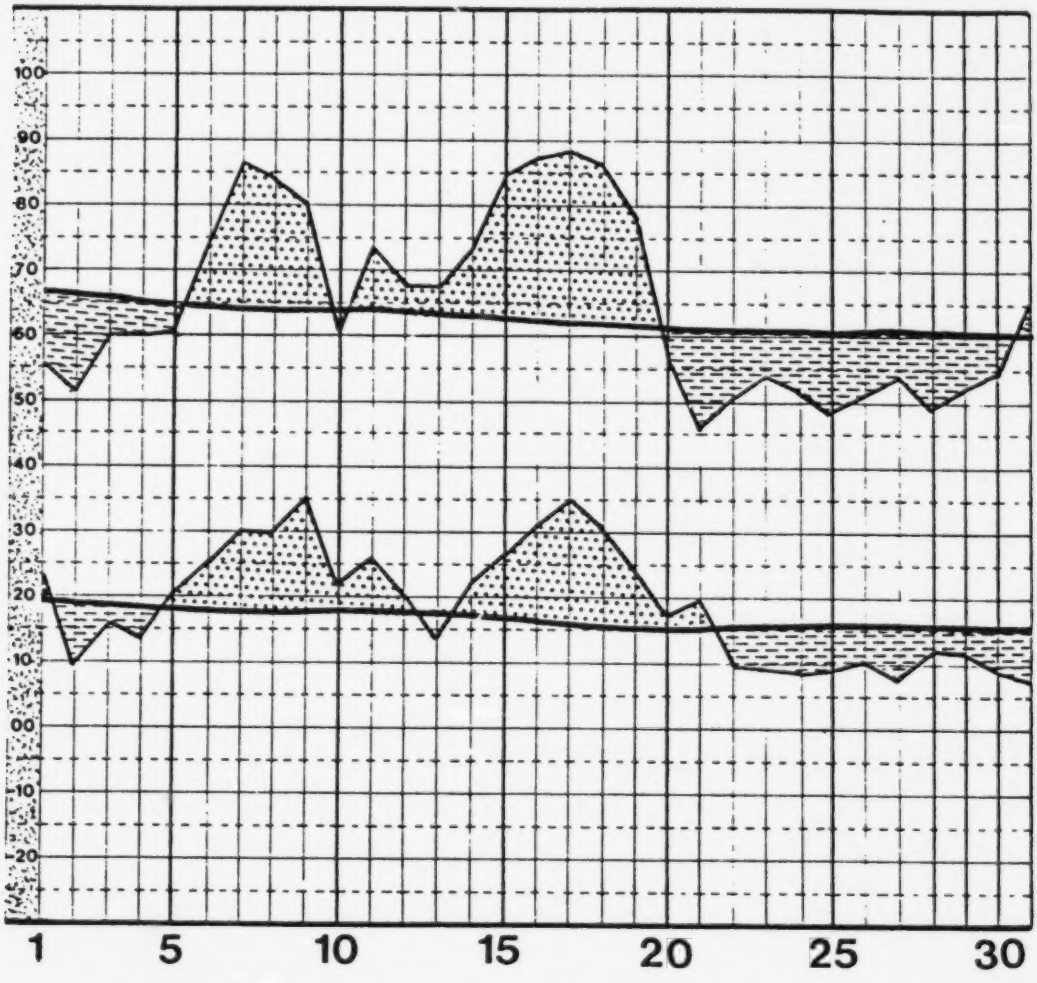

Fig. 23 September Anomalies

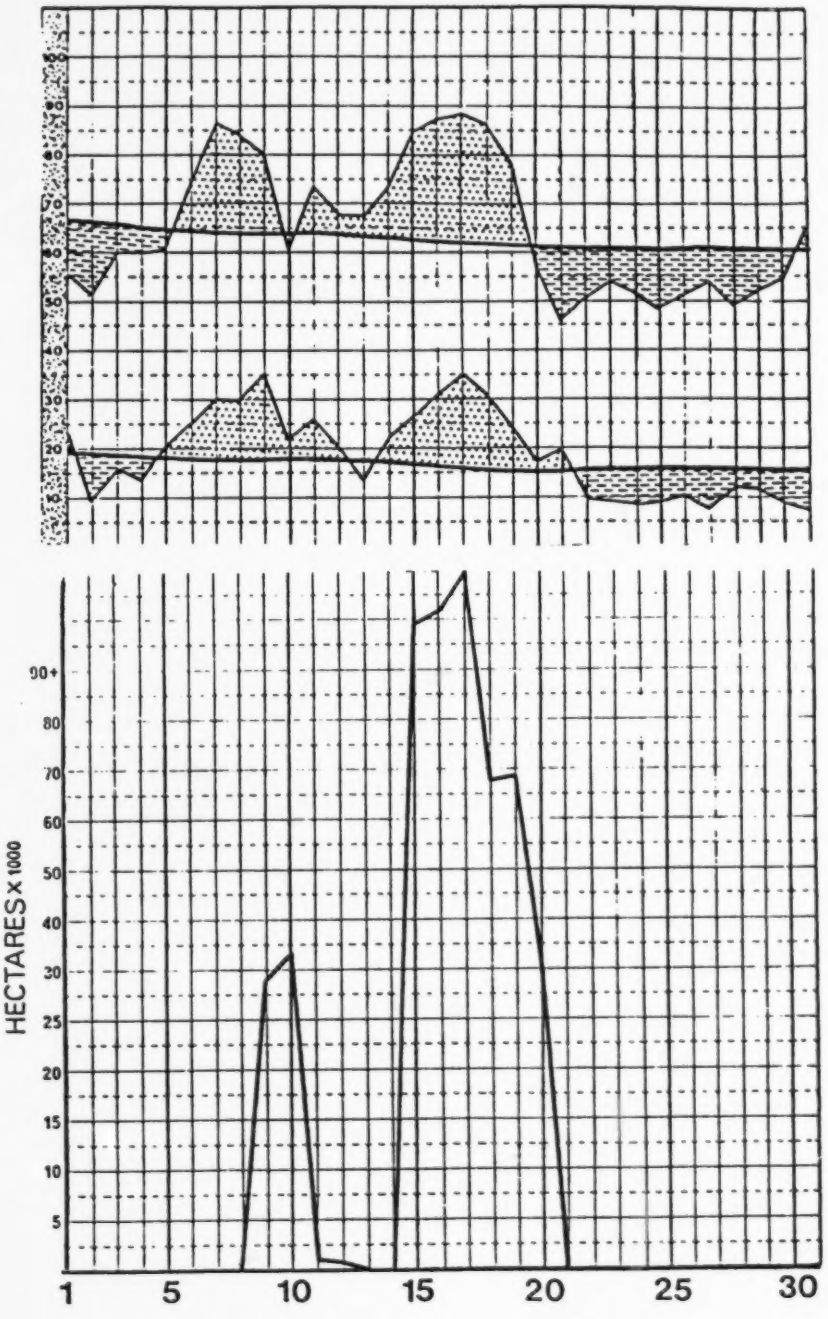

Fig. 24 September Daily Burned Area and Anomalies.

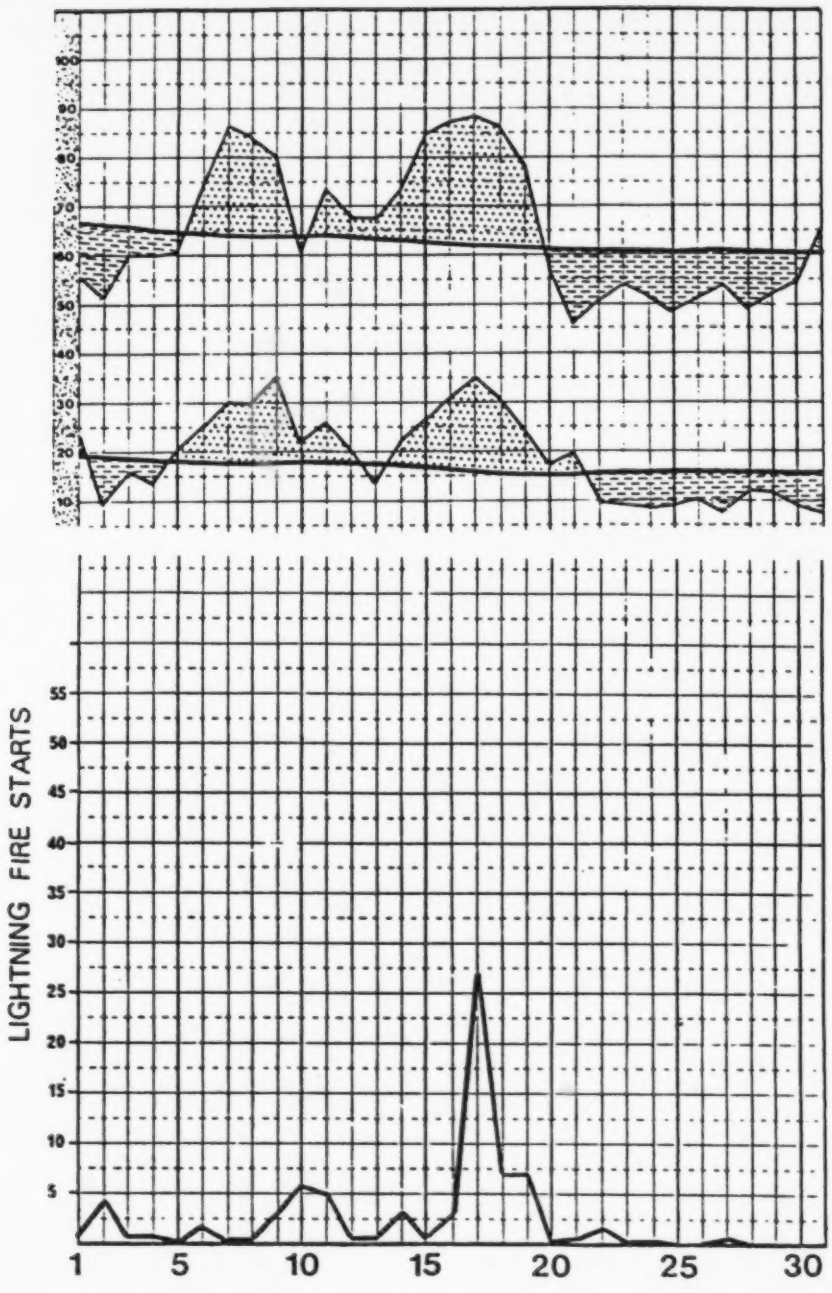

Fig. 25 September Daily Lightning Fire Starts and Anomalies.

The suppression of the ridge proved to be temporary as the upper trough continued its rapid pace eastward. Ridges aloft and at the surface began to firmly re-establish across the province on September 13, orchestrating the beginning of a September fire-flap in Alberta. Severe fire weather returned to northern and central Alberta by September 15 as a short wave travelled along the western side of the ridge toward the Northwest Territories. The short wave induced development of a surface low in northwestern British Columbia during the morning of September 15. As the high pressure system associated with the upper ridge maintained its position over east-central Alberta, strong pressure gradients materialized across the Footner and Athabasca regions. Propelled by southeast winds of 25 to 40 km/h in the afternoon, fires ran through 61 000 ha.

The short wave and low pressure system turned eastward, moving along the northern extremity of the upper ridge. The low forced a series of weak cold fronts from the Northwest Territories into the northern half of the province during September 16 and 17. The frontal passages placed fire areas under a cooler but dry northwesterly flow as an intense gradient structure persisted. Fire continued to advance over thousands of hectares on both days. The lightning fire incidence (Fig. 25) shows a rash of activity (28 starts) on September 17, coinciding with the maximum height of the September ridge. The apparent rash of lightning fires starts was caused by an isolated, dry thunderstorm over the Swan Hills in central Alberta. A weak cold front that stalled in central Alberta combined with extreme afternoon surface heating over the hilly terrain to trigger the storm. All of the resulting fire starts were swiftly brought under control by initial attack.

Cooler air persisted in flooding southward on September 18 with the building of an Arctic surface high pressure area in northern Alberta and Saskatchewan. Surface winds became southeasterly over the fire areas and gusts to 60 km/h drove active fires through 81 000 ha of timberland. By this time, the upper ridge was beginning to weaken. The eastward movement

of a trough in the Pacific began to pinch the ridge into a narrower and weaker structure. A surface low began to develop in west-central Alberta during the late afternoon of September 18 and intensified on September 19 as the upper trough entered the province through central British Columbia. Cool and moist air spilled across the divide. Scattered wet thunderstorms accompanied the cool Pacific air along the foothills as far north as Peace River. Since the surface low developed and deepened in central Alberta, the fire-ravaged northern districts received cloudy and wet weather. The ridge collapsed by September 20. Cool, damp conditions continued in northern Alberta through the remainder of September under a predominently upper trough pattern and effectively brought the 1981 season to an end.

4. RESULTS AND CONCLUSIONS

4.1 General Discussion

The data clearly point to a relatively brief transition period from the upper ridge to the trough pattern. Past studies (McLean and Coulcher 1968; Newark 1975) have recognized that fire-weather conditions associated with a quasi-stationary upper ridge lead to significant build- up, increased fire danger and more active behavior among going fires.

Newark's (1975) work, based on a Hovmoller analysis of northwestern Ontario during its severe 1974 fire season, concludes that a close relationship exists between three events: peaks in the height of th upper ridge; extreme values of the Fire Weather Index (FWI) 1978; and severe fire-control difficulties. The Newark study also broadly defines two fire-weather cycles in the lifetime of a ridge within which FWI values increase during the building half-cycle and decrease during the half-cycle of collapse.

This approach does not fully account for the cases of extreme fire behavior recently observed in Alberta and fails to recognize the role of the fire behavior components in the CFFDRS. Extreme values of the FWI reached at the peak of an upper ridge are primarily the result of cumulative drying arising from an extended period of high temperatures, low humidities and sparse precipitation. A decreasing fuel moisture is reflected by an increasing value of the Build-Up Index (BUI) and a correspondingly greater fuel supply. Although going fires may display more active behavior under a strong upper ridge, blow-ups are seldom observed. The pivotal weather element in blow-up situations that is usually lacking under the peak ridge/peak FWI scenario is wind. Surface winds as well as the flow aloft tend to be relatively light under an established upper ridge, particularly within the surface high pressure

system associated with the ridge. Extreme rates of spread, associated with high Initial Spread Index (ISI) values, require strong surface winds as well as low relative humidities. Strong surface winds in turn generally result from an intense pressure gradient structure. High pressure areas normally have a weak gradient structure.

Intense pressure gradients are most characteristic of deep surface lows or troughs. A vigorous surface low often accompanies or slightly precedes an upper low or well-defined trough. If an upper level system is of sufficient intensity to breakdown a blocking ridge, the surface low will probably be intense as well and capable of producing strong winds. Especially strong winds develop in the vicinity of cold fronts. In Alberta, the movement of low pressure systems is predominently from west to east. Consequently, increasing pressure gradients develop in eastern areas of the province as cold fronts approach from British Columia. Brisk southeasterly to southerly winds result in the eastern areas, while strong westerlies sweep into western regions of the province following the cold frontal passage. Westerly winds and cooling eventually spread into eastern Alberta with the eastward progression of the low. The potential for blow-up fire conditions arises in areas south of the track of the low during the period between when pressure gradients begin to intensify and the arrival of cooler, damper air in the wake of the system. Explosive burning conditions can easily develop in this interval with the combination of high winds, pre-frontal low-level jetting, extreme temperatures and low humidities. Most extreme peak values of the FWI in Alberta occured under the circumstance outlined above during the 1980 and 1981 fire seasons. The August 27, 1981, ridge breakdown saw severe burning conditions persist for nearly 10 hours in eastern districts of the province. Although the probability of precipitation is increased with the ridge breakdown, it is by no means a certainty and the risk of little or no moisture relief is quite real.

4.2 Fire-Weather Stages of an Upper Ridge

In relation to fire weather, the life cycle of an upper ridge is marked by three apparent stages:

1. An establishment period, characterized by increasing temperatures, low humidities, light winds, rapidly decreasing fuel moisture and low lightning risk. Man-caused fire risk may become critical at this stage.
2. Initial weakening by short wave disturbances, leading to decreased atmospheric stability, increased lightning activity but little or no cooling or reduction in fire danger. Periods of ridge recovery may also occur.
3. Final breakdown, accompanied by a period of severe burning conditions and lightning occurence followed by cooling and a reduction in fire danger.

The strength and persistence of an individual ridge profoundly influences the duration or even existence of these apparent stages. The major ridges of 1981 tended to display three discernible stages:

a)	July ridge	Stage 1 :	July 1 to 2
		2 :	July 2 to 3
		3 :	July 4 to 5
b)	August ridge	Stage 1 :	August 4 to 11
		2 :	August 12 to 26
		3 :	August 27 to 28
c)	September ridge	Stage 1 :	September 1 to 9
		2 :	September 10 to 19
		3 :	September 20 to 21

The abrupt destruction of an upper ridge also appears to generate a risk of more severe fire weather than in the case of a gradual breakdown. A measure of the rapidity of a ridge breakdown is given by the slope of

the line between the peak ridge height and the succeeding trough height. A rapid weakening or destruction of an upper ridge pattern is usually indicative of an intense, fast-moving upper low or trough. This implies the presence of a correspondingly intense surface low which may produce stronger winds than surface systems associated with weaker and slower depressions. The account of "Black Thursday" illustrates how a rapid ridge breakdown can produce particularly extreme burning conditions.

4.3 Implications for Fire Suppression Management

The shifts in the synoptic weather pattern associated with the blow-up fire runs of 1981 are far from unique or peculiar. Fire-weather forecasters have undoubtedly witnessed a similar series of events surrounding extreme rate of spread fires in the past. The question is how aware are fire control personnel of the ramifications on suppression strategy posed by the eventual breakdown of a blocking ridge.

Consider the following scenario: a prolonged period of warm, dry weather under a blocking ridge has produced extreme fire danger over an extensive area. A number of going fires ignited before or early in the lifetime of the ridge have become moderately active. Suppression efforts are managing to contain the situation but the fire control system is operating at or near maximum capacity. Are things likely to get worse before they get better? The point is raised again that fire managers as well as fire-weather forecasters have demonstrated a propensity to look beyond the imminent event of the ridge breakdown toward the potential moisture relief offered by the change in synoptic pattern. The data presented here has shown that the risk cannot be ignored of severe fire weather developing prior to any expected or actual relief resulting from a blocking ridge breakdown.

4.4 Role of the Fire-Weather Forecast

The danger to suppression activities during the demise of a blocking ridge has been identified. How much pre-warning of the event can be given? The fire-weather forecaster can usually predict major changes in the upper atmospheric circulation pattern 48 hours prior to the event. This amount of lead time should provide fire strategists with some degree of planning flexibility and allow an assessment of the total fire situation before potentially serious problems develop.

Besides the logistical matters that must be studied given such pre-warning, fire safety should figure prominently in the assessment process. It could be forcefully argued that several of the blow-up fires observed in recent seasons were virtually beyond the control of any suppression effort that was or could have possibly been expended. The pattern and nature of wind shifts frequently observed during ridge breakdowns enable a measure of precautionary planning as to manpower and resource deployment on the fire line.

4.5 Summary of Conclusions

1. Fire-weather conditions associated with an upper ridge are conducive to increasing fire danger and produce more active behavior of going fires.
2. The most severe and critical fire-weather situations arise with the breakdown of the blocking ridge pattern.
3. The lifetime of an upper ridge appears to consist of three distinct fire weather stages:

   Stage 1 - Initial establishment leading to warm, dry stable conditions, rapidly increasing fire-danger levels, light winds and suppression of thunderstorm activity.

Stage 2 - Progressive weakening as short wave trough penetrate deeper into the ridge, triggering lightning activity. Little or no reduction in fire danger is observed. Ridge recovery may also occur.

Stage 3 - Final breakdown of the ridge pattern by an upper low or trough accompanied by a surface low pressure system. A relatively brief period of strong winds, high temperatures and low humidities may result in explosive burning conditions over a wide area during the breakdown. The situation is further aggravated if no precipitation occurs within the breakdown period.

4. The establishment of a blocking ridge confronts fire suppression management with serious implications, specifically with respect to the possible effects of the eventual ridge breakdown on the fire environment.

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POOR

QUALITY

ORIGINAL